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DESIGN OF WATER QUALITY AND SOIL MACRONUTRIENTS MEASURING DEVICE USING TDS AND NPK SENSOR

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ABSTRACT

The purity of canned water depends on the source of the water and the treatment process adapted by the manufacturer. Canned water is expected to be free from harmful contaminants and pathogens. Drinking impure canned water can lead to several waterborne diseases such as cholera, Typhoid, Hepatitis, Cryptosporidiosis and Giardiasis. For the health of the ecosystem as a whole and the growth of plants, the chemical composition of soil is important. The chemical composition of the soil includes various parameters such as pH, nutrient content, and toxic substances. The chemical properties of soil can have an impact on plant growth and development, soil fertility, and ecosystem's overall health. Plants require a balance of essential nutrients, such as nitrogen (N), phosphorus (P), and potassium (K), to grow and develop properly. If the soil lacks these nutrients, plant growth can be stunted or even completely inhibited. In this paper, we propose a model that uses the Total Dissolved Solids (TDS) sensor and NPK (Nitrogen, Phosphorus, and Potassium) sensor to measure the quality of drinking water and the chemical composition of the soil. Temperature and moisture sensors are used to measure the temperature and moisture level for automatic irrigation.

Keywords: purity of canned water, chemical composition of soil, TDS sensor, NPK sensor.

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1. INTRODUCTION

The Bureau of Indian Standard (BIS) regulates the standard for all packaged drinking water in India. BIS sets strict standards for the quality and purity of drinking water to ensure the water is safe for drinking. As per the BIS standards, the drinking water should be free from chemical pollutants and microorganisms. Drinking water also meets the standards for chemical parameters such as Total dissolved solids, pH, chemicals such as arsenic, lead and fluoride. To ensure the BIS standard, packaged drinking water manufactures must get license from Food Safety and Standards Authority of India (FSSAI). It's the duty of FSSAI to conduct inspections and testing to ensure the packaged drinking water meets the BIS standard. Due to rapid increase in urbanization, adulteration, industrialization, population explosion the quality of products has declined to meet high demands in a short span, thereby causing ill-effect on consumers.

The microorganisms in water can cause infections in gastrointestinal tract, which leads to vomiting, diarrhea, abdominal cramps and dehydration. Impure water can cause diseases such as Cholera, Typhoid, Hepatitis A, Cryptosporidiosis and Giardiasis. Cholera is a bacterial infection that cause severe diarrhea and vomiting and it can be life threatening if it is not treated properly. Furthermore, Typhoid is a bacterial infection that cause diarrhea, severe fever and stomach pain. Hepatitis A is a viral infection that cause fatigue, fever, jaundice and inflammation of the liver. Cryptosporidiosis and Giardiasis are a parasitic infection that cause nausea, stomach cramp and diarrhea. The waterborne diseases are more dangerous for people with weakened immune system, younger and elderly people. Consuming safe and clean wateris important to prevent the waterborne diseases. People in India faces considerable problems with access to clean water, especially in rural regions. As of 2018, according to a report by the government of India's Ministry of Drinking Water and Sanitation, about 79% of households had access to improved drinking water sources, sources are shielded from external contamination.

The TDS level in water can give an indication of its overall quality. In general, a higher TDS level indicates that there are more dissolved substances in the water, which can affect its taste, odour, and colour. However, not all dissolved substances in water are harmful to human health. Some minerals, such as calcium and magnesium, are actually beneficial to our health. The World Health Organization (WHO) recommends that the TDS level in drinking water should not exceed 1000 ppm. Water with TDS levels between 300-500 ppm is considered good, while water with TDS levels above 1000 ppm is generally considered poor quality and may not be suitable for drinking. It is important to note that TDS is just one of several parameters used to evaluate water quality. Other parameters such as pH, dissolved oxygen, and the presence of specific contaminants should also be considered when assessing water quality. Quality of the packaged water can be measured using TDS level.

Table-1. Nutrients and TDS level for the growth of various crops.

Crop	N	P	K	Ca	Mg	TDS (PPM)
Cucumber	230	40	315	175	42	1190-1160
Eggplant	175	30	235	150	28	1750-2400
Herbs	210	80	275	180	67	800-1200
Lettuce	200	50	300	200	65	560-840
Mellon	186	39	235	180	25	1400-1750
Pepper	175	39	235	150	28	1500-1700

Soil is composed of organic and inorganic materials, that can vary with different factors such as topography, climate, and vegetation. The chemical composition of soil is classified into three categories: organic matter, inorganic matter, and soil solution. Organic matter of soil includes dead plants, animal materials and living microorganisms such as earthworms, fungi and bacteria. Organic matter in soil provides nutrients to plants andessential for soil structure and water retention. Carbon, Nitrogen, Phosphorous, Potassium and Sulphur are the primary components of Organic matter. Inorganic matter composed of rocks that broken over time and minerals. Inorganic matter in soil provides macronutrients such as Nitrogen, phosphorus and Potassium as well as micronutrients such as iron, zinc and manganese. Soil solution refers to liquid portion of soil. Soil solution consists of minerals and solutions that are important for plant growth. Water, dissolved minerals and nutrients are the primary components of soil solution. Soil solution is formed when irrigation or rainwater percolates through the soil and dissolves the minerals and nutrients from the soil particles. The nutrients and the TDS level (PPM) for the growth of various crops is shown in Table-1. Furthermore, TDS level (PPM) for the growth of various vegetable crops is shown in Table-2.

Table-2. TDS level for the growth of various vegetable crops.

VEGETABLES	TDS (PPM)
Asparagus	980 – 1260
Beans	1260 – 1540
Beets	1260 – 3500
Broccoli	1960 – 2540
Sprouts	1750 – 2100
Cabbage	1750 – 2100
Carrot	1120 – 1400
Cauliflower	1280 – 1400
Celery	1260 – 1400
Cucumber	1190 - 1760
Eggplant	1750 – 2400
Garlic	980 – 1260
Lettuce	560 – 840
Okra	1400 – 1680
Onions	980 – 1260
Peas	980 – 1260
Potatoes	1400 – 1750
Pumpkin	1260 – 1680
Radish	840 – 1540
Spinach	1260 – 1610
Tomato	1400 – 3500

The land usage has completely been commercialized and people in urban areas have no chance to be involved in agricultural activities. Also, the rise in number of industries in and around villages, spoil the ground water resources and the air in that area. Taking all these issues into consideration, we have devised this instrument to ensure the correctness of the samples that are in use, so as to receive a healthy produce or yield. This simple model can be used for organic cultivation and also implemented on terrace farming, hydroponics, full-fledged cultivation, involving people in cities as well to take up small scale terrace or garden farming so as to

achieve a comparatively pure, organic produce and lead a healthy lifestyle. Our main ideology is to device a single, tiny hand-held prototype which may turn to be purposeful in multiple angles and solve people's thirst in fields involving agriculture as well as water-based sources.

2. RELATED WORKS

A system was designed to the identify quality of water using the internet of Things. This was achieved by implementing a monitoring system with various sensors, including a TDS meter, DC motor, LM35 temperature sensor, and GSM. If the water quality falls below the TDS meter's set values, an alert message is sent to the landowners through GSM. By utilizing this system, it is possible to maintain adaptable and good water quality in the environment [6]. Developed a system for water pH and TDS indicator device using Microcontroller Arduino, specifically designated for a fishpond [9]. Nutrition feeding automation system of a prototype scaled Nutrient Film Technique (NFT) hydroponics was designed using Arduino UNO R3 board, water level detector and TDS sensor [3]. An efficient IoT system was suggested to enable real-time monitoring of water quality utilizing physiochemical sensors. The system was developed using Arduino as the microcontroller and incorporates various sensors, including turbidity, temperature, pH, conductivity, and TDS, to achieve the objective [11]. A cheap and reliable IoT-enabled TDS measurement system was proposed for smart campus environment [4]. As software-defined cloud environments, big and real-time data analytics, artificial intelligence (AI) advancements, knowledge visualization tools, and avariety of smartphone applications continue to advance, farmers can anticipate significant transformations in their lives. Various ways and means of empowering our farmers with real-time information were discussed [7].

A Smart Agriculture IoT System was proposed using Soil moisture sensor, Water level sensor, Humidity sensor and Temperature sensor [8]. A soil monitoring system was proposed utilizing sensors that measure a variety of parameters and sensors including temperature, moisture, light, humidity, and pH [1]. An integrated Internet of Things (IoT) system for the supervision and regulation of hydroponic gardens was presented. By harnessing the power of IoT and automation, this system intends to address issues related to resource management. The primary objective of this system is to maintain the optimal growth conditions for plants by continuously monitoring parameters such as pH, water level, air temperature, and relative humidity [2]. Discussed the green development mode of the food industry using IoT, and environmental pollution index was measured using entropy method [12]. A system was designed using Internet of Things for monitoring the soil parameters including pH level, soil moisture, temperature and humidity [5]. Furthermore, system was designed to monitor soil parameters such as pH, moisture content and surrounding temperature [10].

This paper proposes a model with TDS sensor, NPK sensor, Moisture Sensor and Temperature sensor to measure the quality of water, Macronutrients (NPK) in the soil, Temperature and Moisture for automatic irrigation. This simple model can be used fororganic cultivation and also implemented on terrace farming, hydroponics, full-fledged cultivation. Our main ideology is to device a single, tiny hand-held prototype which may turn to be purposeful in multiple angles and solve people's thirst in fields involving agriculture as well as water-based sources.

3. METHODOLOGY

The workflow diagram of water quality and soil macronutrients measuring device isshown in Figure-1. The proposed design uses Arduino Uno microcontroller, TDS for measuring the water quality, NPK sensor measuring macronutrients such as nitrogen, phosphorus, and potassium in the soil. Furthermore, Temperature and Moisture sensor is used for checking the temperature and for automatic irrigation process. Arduino Uno is a microcontroller board based on the ATmega328P microcontroller. It is suitable for both novice and advanced users who wish to explore the realm of electronics and programming. It has 14 digital input/output pins, 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, and a reset button. Its versatility makes it a popular choice for various DIY projects, as well as applications such as prototyping, robotics, and automation. Moisture sensors are electronic devices used to measure the level of moisture present in a material or its surroundings. They can be designed to measure moisture in different types of materials such as soil, air, wood, and more. These sensors detect moisture by measuring the changes in the dielectric constant of the material, which varies depending on the moisture content. Integrating moisture sensors with other electronic systems such as data loggers, weather stations, and irrigation systems can provide real-time data to automate moisture control processes.

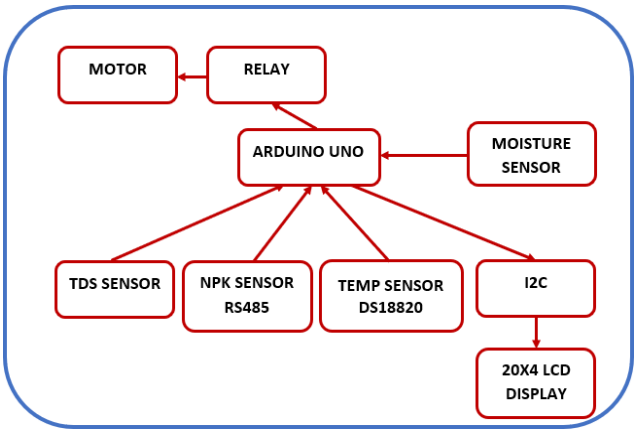


Figure-1. Workflow diagram of water quality and soil macronutrients measuring device.

An NPK sensor with RS485 interface is a type of sensor that measures the concentration of nitrogen, phosphorus, and potassium (NPK) in soil or other types of growing media. The RS485 interface is a communication

protocol used for serial communication over long distances. By using the RS485 interface, NPK sensors can transmit data over a longer distance, making them ideal for applications where the sensor needs to be placed far away from the data acquisition system. NPK sensors with RS485 interface typically have a built-in microcontroller that measures the NPK concentration and converts it into a digital signal. Thedigital signal is then transmitted over the RS485 interface to the data acquisition system, where it can be stored and analysed. These sensors are commonly used in agriculture and horticulture for monitoring the nutrient levels in soil and optimizing fertilizer application.

A TDS sensor is an electronic device used to measure the total dissolved solids (TDS) in a liquid solution. TDS is the sum of all inorganic and organic substances present in a liquid, including salts, minerals, metals, and other substances. TDS sensors work by measuring the electrical conductivity of the liquid, which is directly proportional to the concentration of dissolved solids. TDS sensors are commonly used in water quality monitoring, such as in aquariums, swimming pools, and hydroponic systems, to ensure that the TDS levels are within acceptable limits. They are also used in industrial applications, such as in the food and beverage industry, to measure the concentration of dissolved solids in liquids used for production processes. TDS sensors are available in various designs, including handheld, portable, and inline models, and can provide real-time readings of the TDS levels in the liquid.

A moisture sensor is an electronic device that measures the moisture content in a substance or material, typically soil or other growing media in agriculture, horticulture, and landscaping applications. It works by measuring the electrical conductivity of the soil or other material, which is directly related to the moisture content. Moisture sensors are commonly used in agriculture and landscaping to help growers and landscapers optimize water usage and ensure that plants are receiving the appropriate amount of water. By measuring the moisture content of the soil or other material, growers and landscapers can avoid overwatering or underwatering, which can lead to reduced crop yields, plant stress, and other problems. The DS18B20 is a digital temperature sensor that is commonly used in a variety of electronic applications. It is a 1-wire sensor, which means that it communicates with a microcontroller or other device using only one data line. The DS18B20 can measure temperatures ranging from -55°C to +125°C with an accuracy of ±0.5°C. The DS18B20 has several features that make it popular for use in various applications. It is commonly used in temperature monitoring and control systems, such as in home automation, industrial automation, and weather monitoring applications.

4. RESULTS AND DISCUSSIONS

The overall hardware structure of the water quality and soil macronutrients measuring deviceis shown in Figure-2.

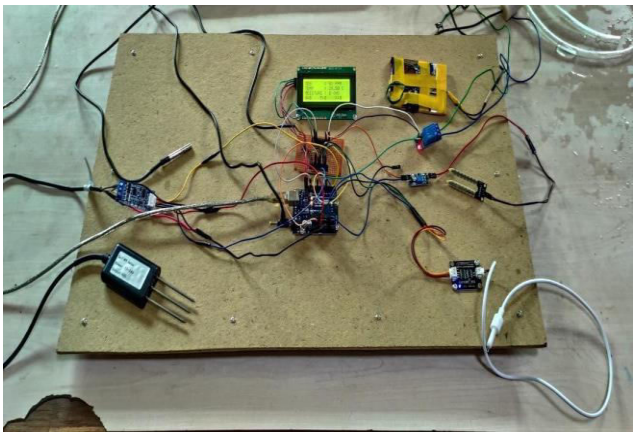
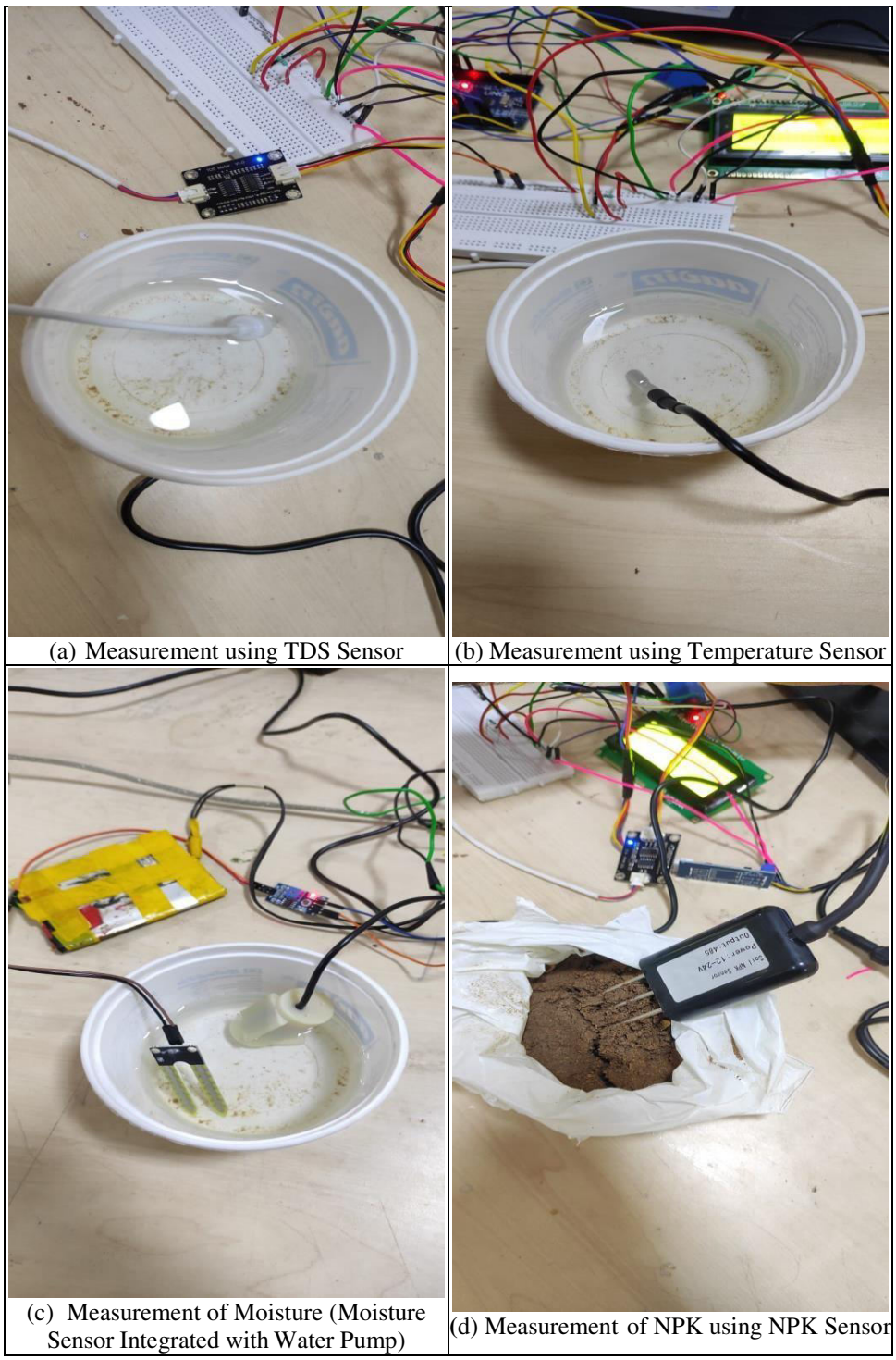


Figure-2. Hardware structure of water quality and soil macronutrients measuring device.

Measurement of Total Dissolved Solids (TDS) levels in water using TDS sensor, Temperature in soil using Temperature sensor, Macronutrients such as Nitrogen (N), Phosphorus (P), and Potassium (K) in soil using NPK sensor and Moisture level in the soil using Moisture sensor is shown in Figure-3. Water Pump is integrated with moisture sensor for automatic irrigation in the farms. The different types of soil and water samples are tested and measured the NPK and TDS value. The measured parameters from different water and soil samples are tabulated for quality assessment.



(a) Measurement using TDS Sensor

(b) Measurement using Temperature Sensor

(c) Measurement of Moisture (Moisture Sensor Integrated with Water Pump)

(d) Measurement of NPK using NPK Sensor

Figure-3. Measurement of TDS, temperature, moisture, and NPK using sensors.

NPK is measured from Soil Sample of small potted plant and Soil Sample taken from Farm as shown in Figure-4. The NPK measured from Soil Sample of small potted plant is 124, 44 and 62 and NPK measured from Soil Sample taken from Farm is 108, 38, 54. Temperature and Moisture measured from Soil Sample of small potted plant is 34.06, 3 and temperature and Moisture measured from Soil Sample taken from Farm is 34.13, 4. The measured parameters are tabulated in Table 3. Furthermore, the measured parameters are compared as shown in Figure-5.

(a) NPK Measurement in Soil Sample of small potted plant.

(b) NPK Measurement in Soil Sample taken from Farm.

Figure-4. Measurement of NPK from different soil samples.

Table-3. Parameters measured from soil sample of small potted plant and soil sample takenfrom farm.

Samples	Temperature(C)	Moisture(H)	Nitrogen (mg/kg)	Phosphorus (mg/kg)	Potassium (mg/kg)
NPK Measurement in Soil Sampleof small pottedplants.	34.06	3	124	44	62
NPK Measurement in Soil Sample.	34.13	4	108	38	54

NPK sensors are utilized to detect soil fertility, which is mainly determined by the presence of Nitrogen, Phosphorus, and Potassium. Nitrogen, Phosphorus, and Potassium are the key components of soil fertilizer. By assessing the concentration of these nutrients in the soil, we can gain insights into any nutritional deficiencies or excesses that may affect plant growth and productivity. The proposed system can be used by the farmers to assess the level of macronutrients in the soil and fertilize the soil to improve crop yields.

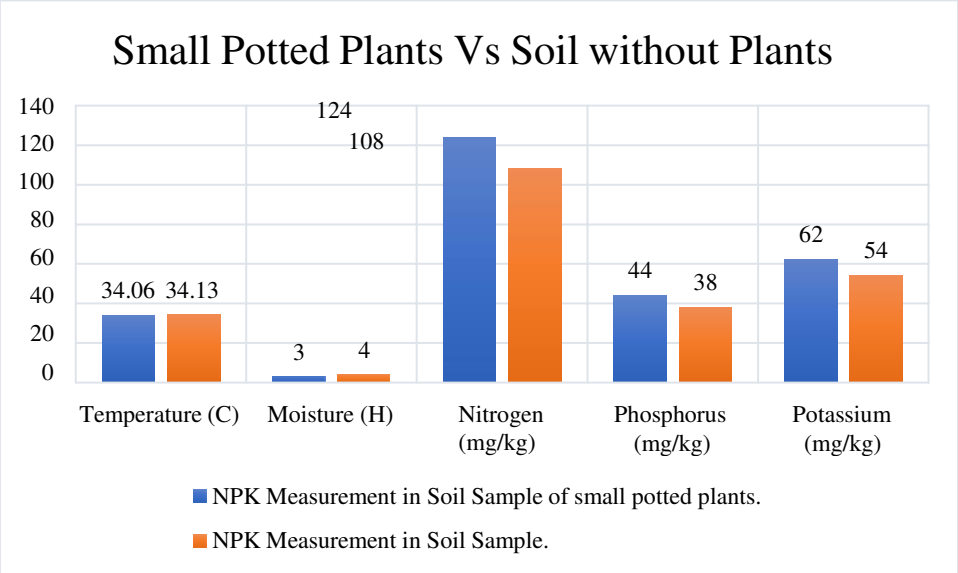
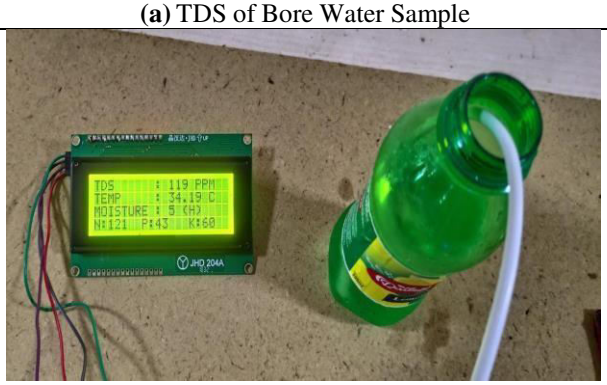


Figure-5. Comparison of NPK measured from different soil samples.

TDS is measured from various water samples such as Bore Water, Packaged DrinkingWater, Carbonated Water, Soap Solution, Salt Water, and Delta Water Sample used for irrigation in the Thanjavur belt as shown in Figure-6. The TDS (in PPM) measured from the above-mentioned water samples are 260, 41, 119, 325, 350, 321 as listed in Table-4. The measured TDS values are compared in Figure-7.

(a) TDS of Bore Water Sample

(b) TDS of Packaged Drinking Water Sample



(c) TDS of Carbonated Water Sample

(d) TDS of Soap Solution Sample

(e) TDS of Salt Water Sample

(f) TDS of Delta Water Sample used forirrigation in the Thanjavur belt

Figure-6. Measurement of TDS from different water samples.

Packaged drinking water's TDS levels are influenced by the source of the water and the treatment methods used by the manufacturer. To ensure safe consumption, the TDS levels of packaged drinking water are regulated by government agencies and may differ across regions. Typically, the acceptable TDS level for packaged drinking water is below 500 ppm (parts per million). Nonetheless, certain brands may lower their TDS levels for taste or marketing reasons. The proposed system can be used domestically to measure the TDS to ensure the quality of the water used in day-to-day life.

Table-4. TDS measured from different water samples.

Sample	TDS (PPM)
Bore Water Sample	260
Drinking Water Sample	41
Carbonated Water Sample	119
Soap Solution Sample	325
Salt Water Solution	350
Water used for irrigation	321

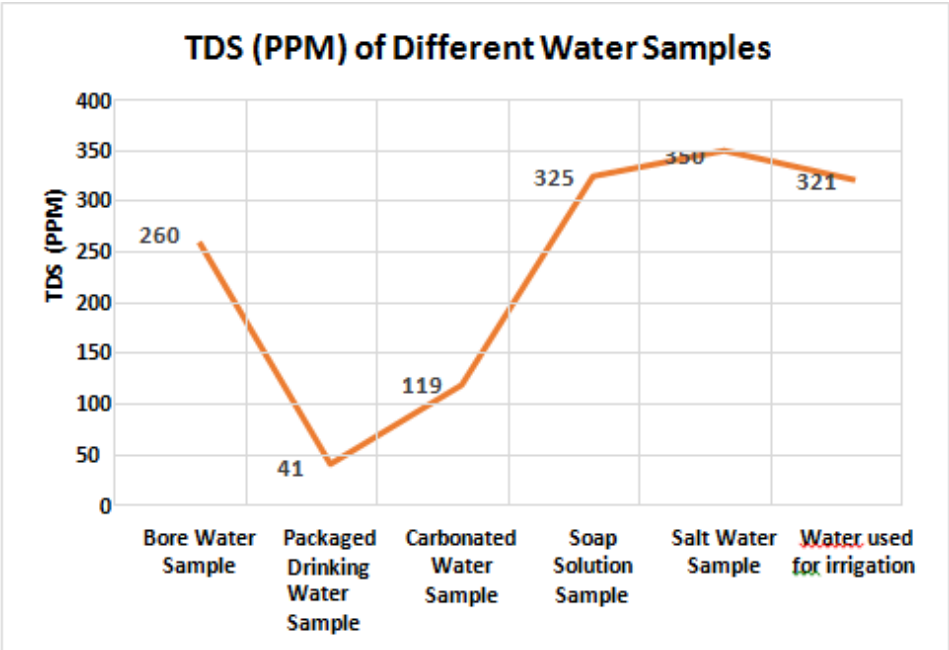


Figure-7. Comparison of TDS measured from different Water Samples.

5. CONCLUSIONS

The proposed system aims at providing a resultant, bearing multiple-parameter notifying device prototype, which shows the Parts Per Million of dissolved solids in water, NPK nutrient levels and at the same time measures the dampness of soil, temperature as well as the moisture content so-as-to simplify the basic needs in and around cultivation, terrace and garden farming, hydroponics. By this means, people get to cherish multiple data in one stroke, hassle-free. This can be adapted to a wide range of products like small personal devices to large scale farms enabling the possibility to accurately measure the growth and physical traits of the plant. The proposed system is engineered to be handheld, which solves most of the problems. This device can be taken to any place. If fixed in the farms, the relay and the motor interconnection led to watering the crops with ample amount of water whenever necessary.

The proposed system can be extended to measure the micronutrients in the soil, as well as to determine the levels of dissolved oxygen and pH in water for ensuring the qualityof the water.

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